spring. The groove in which the roller is fixed contains oil for lubrication. The valve is of cast iron of the usual double-beat type. The faces are flat and narrow, the lower face being of slightly less diameter than the upper, so that the valve is riot in exact equilibrium. The valves also are of cast iron, and the distance between the two seats is made short, to reduce as much as possible the difference in axial expansion between the valve faces and the faces in the seat. The valve is guided in the centre by a projection of the seat. No stuffing-box is required. The valve spindle is provided with water grooves, and slides in a long bush fixed in the cover, leakage being thus prevented.

Governor.—The simple pendulum governor was invented by Watt, and consists essentially of an arm, suspended from a vertical spindle in such a way that it is free to move round the point of suspension in a vertical plane passing through the axis of the spindle. The free end carries a weight or ball. In practice two arms are used for obvious reasons.

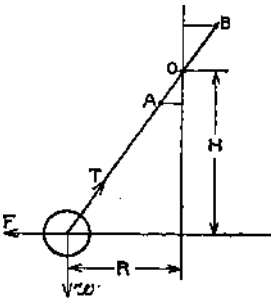

Fig. 18.— Simple Pendulum Governor (suspensor of

The arm may be suspended in three ways: *(a)* from a point O situated in the vertical axis, *(b)* from a point A on the same side of axis as the weight, or *(c)* from a point B on the other side of axis. The point O is important. In the case *(a),* fig. 18, it is the point of suspension and is fixed. In case *(b)* it is the point of intersection of the centre line of the arm produced to the axis, and in case *(c)* it is the point of intersection of the centre line of the arm and the axis. With this latter arrangement the governor is said to have crossed arms. In the cases *(b)* and (£), O is not fixed, but varies with the angular position of the arms with regard to the axis. In the former case, O moves in the direction opposite to that of the weight, that is, when the ball moves outwards and upwards the point O descends. With crossed arms the

point 0 moves in the same direction on the axis as the ball moves vertically.

The vertical distance H between the point O and the horizontal plane in which at any instant the balls revolve, is called the height of cone, and the fundamental fact, relating to the vertical gravity-controlled governor, is that H varies inversely as the square of the speed of revolution.

In fig. 18 the ball is in equilibrium under the action of the three forces, the weight *w,* the centrifugal force F, and the reaction or tension T along the arms. Taking moments about O, FH = mR, or

But

$$F = \frac{H}{}$$

where *v* is in feet per second and $v^2 = 47r^2R^2N^2$. Therefore

H = —C^ = -™r, and thus varies inversely as the square of the revolutions. In the above expression R and H are in feet and N in revolutions per second.